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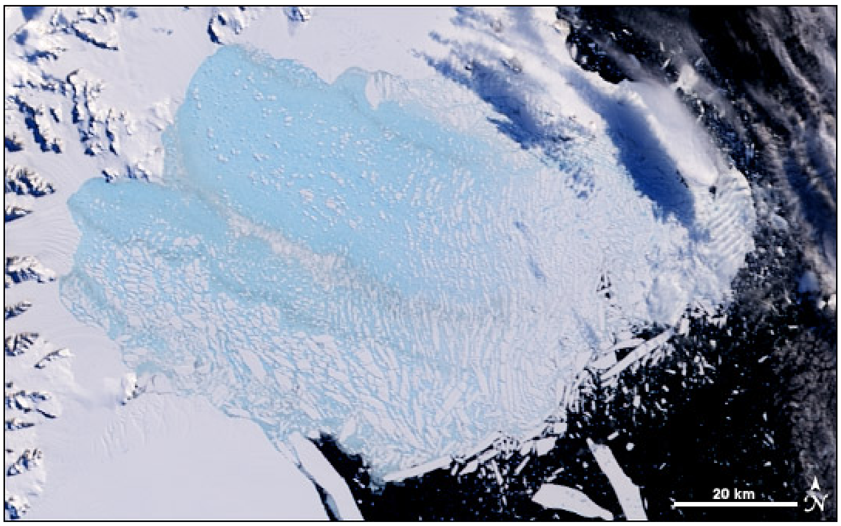
# Global Warming

by Holli Riebeek • design by Robert Simmon • *May 11, 2007*

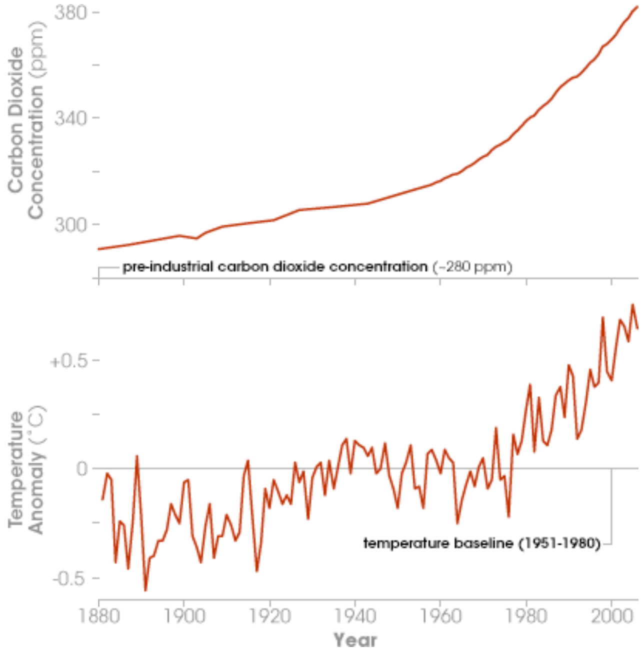
The original version of this fact sheet, published in 2002 and written by John Weier, is archived as a PDF.

Over the last five years, 600 scientists from the Intergovernmental Panel on Climate Change sifted through thousands of studies about global warming published in forums ranging from scientific journals to industry publications and distilled the world's accumulated knowledge into this conclusion: "Warming of the climate system is unequivocal."




Far from being some future fear, global warming is happening now, and scientists have evidence that humans are to blame. For decades, cars and factories have spewed billions of tons of greenhouse gases into the atmosphere, and these gases caused temperatures to rise between 0.6°C and 0.9°C (1.08°F to 1.62°F) over the past century. The rate of warming in the last 50 years was double the rate observed over the last 100 years. Temperatures are certain to go up further.

The effects of global warming are already being felt worldwide. The Larsen-B Ice Shelf on the Antarctic Peninsula collapsed over 35 days in early 2002, prompted by 3°C of warming since the 1940s. (NASA image by Jesse Allen, based on MODIS data.)




Cars, factories, and power plants pump billions of tons of carbon dioxide into the atmosphere every year. Since 1750, carbon dioxide levels have increased 35 percent, while temperatures have gone up between 0.6°C and 0.9°C. Scientists have very high confidence that increased concentrations of greenhouse gases are causing the planet to warm. (Photograph ©2002 Travel Geographer. NASA graphs by Robert Simmon, based on carbon dioxide data from Dr. Pieter Tans, NOAA/ESRL and temperature data from NASA Goddard Institute for Space Studies.)

But why should we worry about a seemingly small increase in temperature? It turns out that the global average temperature is quite stable over long periods of time, and small changes in that temperature correspond to enormous changes in the environment. For example, during the last ice age, when ice sheets a mile thick covered North America all the way down to the northern states, the world was only 9 to 15 degrees Fahrenheit colder than today. Much of modern human civilization owes its existence to the stability in the average global temperature since the end of the last ice age—a stability that allowed human cultures to transition from roaming, hunter-gatherer societies into more permanent, agriculture-supported communities. Even the temperature change of a degree or two that has occurred over the last century is capable of producing significant changes in our environment and way of life.

In the future, it is very likely that rising temperatures will lead to more frequent heat waves, and virtually certain that the seas will rise, which could leave low-lying nations awash in seawater. Warmer temperatures will alter weather patterns, making it likely that there will be more intense droughts and more intense rain events. Moreover, global warming will last thousands of years. To gain an understanding

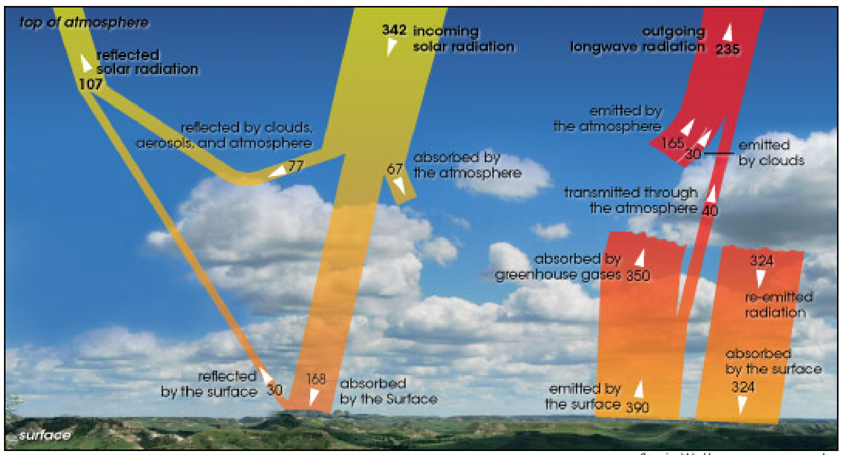
One inevitable consequence of global warming is sea-level rise. In the face of higher sea levels and more intense storms, coastal communities face greater risk of rapid beach erosion and damage from destructive storms like the intense nor'easter of April 2007. (Photograph ©2007 metimbers2000.)

of how global warming might impact humanity, it is necessary to understand what global warming is, how scientists measure it, and how forecasts for the future are made.

### What is Global Warming?

Global warmth begins with sunlight. When light from the Sun reaches the Earth, roughly 30 percent of it is reflected back into space by clouds, atmospheric particles, reflective ground surfaces, and even ocean surf. The remaining 70 percent of the light is absorbed by the land, air, and oceans, heating our planet's surface and atmosphere and making life on Earth possible. Solar energy does not stay bound up in Earth's environment forever. Instead, as the rocks, the air, and the sea warm, they emit thermal radiation, or infrared heat. Much of this thermal radiation travels directly out to space, allowing Earth to cool.

energy received from the Sun | energy emitted by the Earth




energy flux in Watts per square meter

Land, air, and oceans absorb most of the energy that comes from the Sun (yellow arrows, left), and the rest is reflected back into space. The land and oceans re-emit the energy they absorb (red arrows, right) in the form of heat, which is then absorbed by greenhouse gases in the atmosphere. In turn, greenhouse gases re-emit the heat, sending it back to the surface. This heat-trapping effect keeps the Earth comfortably warm, but the build-up of greenhouse gases intensifies the effect, driving temperatures up. (Image adapted from Kiel and Trenberth, 1997, by Debbi McLean.)

Some of this outgoing radiation, however, is re-absorbed by water vapor, carbon dioxide, and other gases in the atmosphere (called greenhouse gases because of their heat-trapping capacity) and is then re-radiated back toward the Earth's surface. On the whole, this re-absorption process is good. If there were no greenhouse gases or clouds in the atmosphere, the Earth's average surface temperature would be a very chilly -18°C (0°F) instead of the comfortable 15°C (59°F) that it is today.

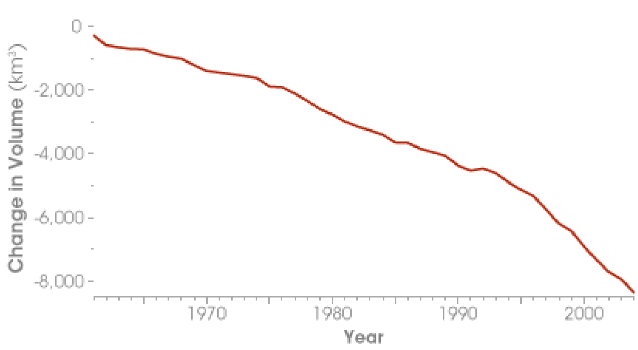
What has scientists concerned now is that over the past 250 years humans have been artificially raising the concentration of greenhouse gases in the atmosphere at an ever-increasing rate. By 2004, humans were pumping out over 8 billion tons of carbon dioxide per year. Some of it was absorbed by "sinks" like forests or the ocean, and the rest accumulated in the atmosphere. We produce millions of pounds of methane by allowing our trash to decompose in landfills and by breeding large herds of methane-belching cattle. Nitrogen-based fertilizers and other soil management practices lead to the release of nitrous oxide into the atmosphere.

Once these greenhouse gases get into the atmosphere, they stay there for decades or longer. According to the Intergovernmental Panel on Climate Change (IPCC), since the industrial revolution began in about

1750, carbon dioxide levels have increased 35 percent and methane levels have increased 148 percent. Paleoclimate readings taken from ice cores and fossil records show that these gases, two of the most abundant greenhouse gases, are at their highest levels in at least the past 650,000 years. Scientists have very high confidence (a phrase the IPCC translates to "greater than 90 percent certainty") that the increased concentrations of greenhouse gases have made it more difficult for thermal radiation to leave the Earth, and as a result, Earth has warmed.

### Evidence for Global Warming

Recent observations of warming support the theory that greenhouse gases are warming the world. Over the last century, the planet has experienced the largest increase in surface temperature in 1,300 years. The average surface temperature of the Earth rose 0.6 to 0.9 degrees Celsius (1.08°F to 1.62°F) between 1906 and 2006, and the rate of temperature increase nearly doubled in the last 50 years. Worldwide measurements of sea level show a rise of about 0.17 meters (0.56 feet) during the twentieth century. The world's glaciers have steadily receded, and Arctic sea ice extent has steadily shrunk by 2.7 percent per decade since 1978.


Spilling from the Columbia Icefield in the Rocky Mountains of western Canada, the Athabasca Glacier has been shrinking by about 15 meters per year. In the past 125 years, the glacier has lost half its volume and has retreated more than 1.5 kilometers. Athabasca is just one of Earth's many glaciers that are dwindling as global temperatures climb. Since 1960, glaciers around the world have lost an estimated 8,000 cubic kilometers of ice. (Photograph ©2005 Hugh Saxby. Glacier graph adapted from Dyurgerov and Meier, 2005.)

Even if greenhouse gas concentrations stabilized today, the planet would continue to warm by about 0.6°C over the next century because it takes years for Earth to fully react to increases in greenhouse gases.

As Earth has warmed, much of the excess energy has gone into heating the upper layers of the ocean. Scientists suspect that currents have transported some of this excess heat from surface waters down deep, removing it from the surface of our planet. Once the lower layers of the ocean have warmed, the excess heat in the upper layers will no longer be drawn down, and Earth will warm about 0.6°C (1° F).

But how do scientists know global warming is caused by humans and that the observed warming isn't a natural variation in Earth's climate? Scientists use three closely connected methods to understand changes in Earth's climate. They look at records of Earth's past climates to see how and why climate changed in the past, they build computer models that allow them to see how the climate works, and they closely monitor Earth's current vital signs with an array of instruments ranging from space-based satellites to deep sea thermometers. Records of past climate change reveal the natural events—such as volcanic eruptions and solar activity—that influenced climate throughout Earth's history. Today, scientists monitor those same natural events as well as human-released greenhouse gases and use computer models to determine how each influences Earth's climate.

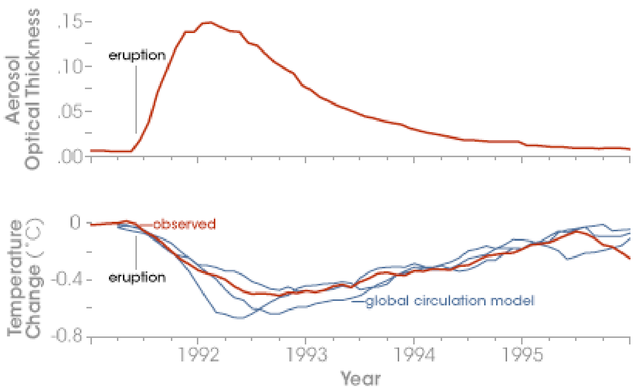
The annual layers of snow packed in glacial ice preserve a record of climate stretching back hundreds of thousands of years. To reconstruct past temperatures and atmospheric conditions, scientists use ice cores, tree rings, ocean sediments, cave rocks, and other natural records that preserve a signature of the climate. By understanding how Earth's climate has changed in the past, scientists gain insight into how and why it might change in the future. (Photograph ©2005 Reto Stöckli.)

### Reconstructing Past Climate Change

Like detectives at a crime scene, scientists reconstruct past climate changes by looking for evidence left in things like glacial ice, ocean sediments, rocks, and trees. For example, glacial ice traps tiny samples of Earth's atmosphere, giving scientists a record of greenhouse gases that stretches back more than 650,000 years, and the chemical make-up of the ice provides clues to the average global temperature. From these and other records, scientists have built a record of Earth's past climates, or "paleoclimates." Paleoclimatology allowed scientists to show that climate changes in the past have been triggered by variations in Earth's orbit, solar variation, volcanic eruptions, and greenhouse gases.

### Building a Climate Model

Next, to understand how sunlight, air, water, and land come together to create Earth's climate, scientists build climate models—computer simulations of the climate system. Climate models include the fundamental laws of physics—conservation of energy, mass, and momentum—as well as dozens of factors that influence Earth's climate. Though the models are complicated, rigorous tests with real-world data hone them into robust tools that allow scientists to experiment with the climate in a way not otherwise possible. For example, when scientists at NASA's Goddard Institute for Space Studies (GISS), NASA's division spearheading climate modeling efforts, put measurements of volcanic particles from Mount Pinatubo's 1991 eruption into their climate models well after the event, the models reported that Earth would have cooled by around 0.5°C a year or so later. The prediction matched cooling that had been observed around the globe after the eruption.




Mount Pinatubo's 1991 eruption pumped volcanic gases high into the atmosphere. The gases interacted with water vapor to form a reflective shade of aerosol particles (top graph) that stretched far beyond the Philippines, where the volcano is located. The global average temperature dipped half a degree Celsius until the particles (sulfates) cleared a few years later. Scientists test and refine global climate models by comparing model predictions of temperature change after events like the eruption to actual observations (bottom graph). When models reliably match observations, scientists gain confidence that the models accurately represent Earth's climate system. (NASA graphs by Robert Simmon, based on data from NASA Goddard Institute for Space Studies.)

As the models reconstruct events that match the climate record, researchers gain confidence that the models are accurately duplicating the complex interactions that drive Earth's climate. Scientists then experiment with the models to gain insight into what is driving climate change. By experimenting with the models—removing greenhouse gases emitted by the burning of fossil fuels or changing the intensity of the Sun to see how each influences the climate—scientists can use the models to explain Earth's current climate and predict its future climate. So far, the only way scientists can get the models to match the rise in temperature seen over the past century is to include the greenhouse gases that humans have put into the atmosphere. This means that, according to the models, humans are responsible for most of the warming observed during the second half of the twentieth century.

| Major Climate Influences | Effect on Surface Temperature | Explanation | Source | Related EO Articles |
|---|---|---|---|---|
| Anthropogenic Greenhouse gases | Warming | Gases absorb energy emitted by the Earth, re-radiating heat toward the surface. | Burning fossil fuels in factories and vehicles, fertilizers, decomposing trash, livestock | Carbon Cycle |
| Ozone | Warming | Ozone absorbs sunlight, so a depletion of ozone cools the atmosphere, while a build-up of ozone warms the surface. | Chlorofluorocarbons destroy stratospheric ozone, while the interaction of sunlight with certain pollutants creates surface ozone | Tango in the Atmosphere; Ozone |
| Surface Albedo | Cooling | *Albedo* is the percent of sunlight the surface reflects. Deforestation increases albedo. Soot that falls on snow and ice reduces albedo. The effect of forest loss outweighs the effect of the soot, resulting in net cooling. | Land use and soot on snow | Arctic Reflection; Earth's Albedo in Decline |

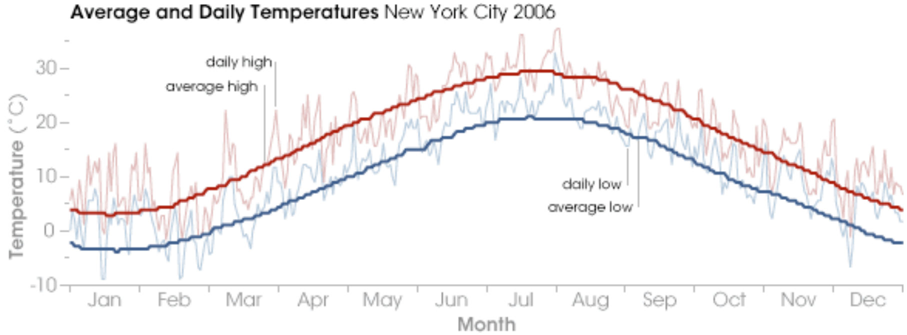
| | | | | |
|---|---|---|---|---|
| Aerosols (particle pollution) | Cooling | Particles in the atmosphere shade the Earth's surface, offsetting global warming as much as 40 percent. Soot absorbs heat and warms the atmosphere. | Volcanoes, burning fossil fuel, other human sources, fires, dust | Aerosols & Climate Change |
| Aerosols (Cloud albedo effect) | Cooling | Because human-produced aerosols are smaller and more numerous than natural aerosols, they increase the amount and brightness of clouds. | Clouds formed around pollution released by cars, factories, power plants, etc. | Clouds are Cooler than Smoke; Changing Our Weather One Smokestack at a Time |
| Solar Variability | Warming and Cooling | An increase in sunlight brings more energy to the Earth and vice-versa. | Natural solar cycles | ACRIMSAT; Solar Max; SORCE; Under a Variable Sun |

But why do scientists trust results from climate models when models seem to have so much trouble forecasting the weather? It turns out that trends are easier to predict than specific events. Weather is a short-term, small-scale set of measurements of environmental conditions, while climate is the average of those conditions over a large area for a long time. The difference between predicting weather and climate is similar to the difference between predicting when a particular person will die versus calculating the average life span of an entire population. Given the large number of variables that influence conditions in Earth's lower atmosphere, and given that chaos also plays a larger role on shorter and smaller scales of time and space, weather is much harder to predict than the averages that make up climate.

Models integrate the many factors that influence Earth's climate to determine how they work together to create today's climate and how they might influence climate change in the future.

However, the longer the time scale, the harder it becomes to predict climate. Scientists understand how certain processes that drive Earth's climate work now, and so they can accurately predict how events like Pinatubo's eruption will cool the globe's average temperature. But they don't understand how every aspect of the climate system will change as the planet warms. Feedback loops—in which change in one part of the climate system produces change in another part—make climate harder to forecast as scientists look farther into the future. For example, what will happen to clouds as Earth warms? Will high-flying, heat-absorbing clouds that would cause additional heating become more frequent than dense, sunlight-blocking clouds? Will changes be regional or global, and how will they affect global climate? As of now, scientists can't answer these questions, and the uncertainties mean that global climate models provide a range of predictions instead of a highly detailed forecast.

**Average and Daily Temperatures** New York City 2006

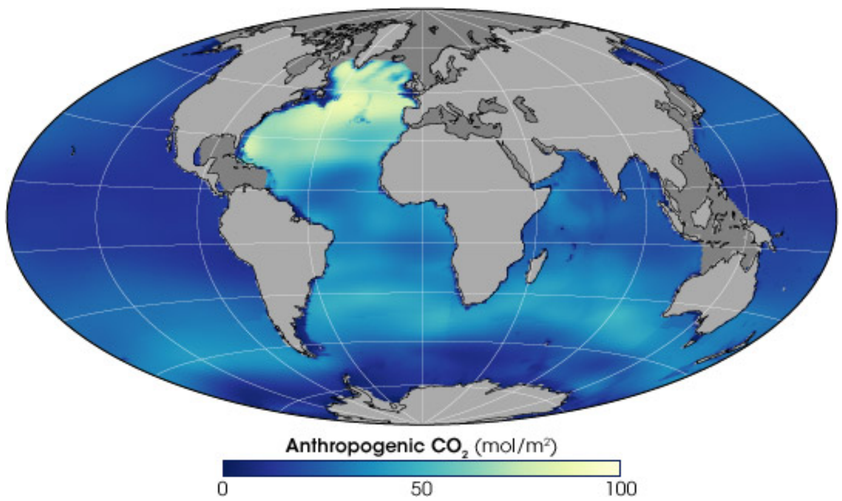



**Observing Global Warming**

Climate models and paleoclimate information tell

Climate is what you expect; weather is what you get. This graph compares long-term scientists what kinds of symptoms to look for when diagnosing global warming. Ocean temperatures and acidity should rise as the oceans soak up more heat and carbon dioxide. Global temperatures are predicted to increase, with the largest temperature increases over land and at the poles. Glaciers and sea ice will melt and sea levels will rise. Like a patient in a hospital, Earth is closely monitored for these symptoms by a fleet of satellites and surface instruments. NASA satellites record a host of vital signs including atmospheric aerosols (particles from things like factories, fires, or erupting volcanoes), atmospheric gases, energy from Earth's surface and the Sun, ocean surface temperatures, global sea levels, the extent of ice sheets, glaciers and sea ice, plant growth, rainfall, cloud structure, and more. On the ground, networks of weather stations maintain temperature and rainfall records, and buoys measure deep ocean temperatures.

average high and low temperatures (dark lines) to the actual daily high and low temperatures in New York City's Central Park during 2006. Although the average temperatures vary gradually as the seasons change, temperatures fluctuate wildly from day-to-day. (NASA graph by Robert Simmon, based on data from the National Weather Service Forecast Office.)

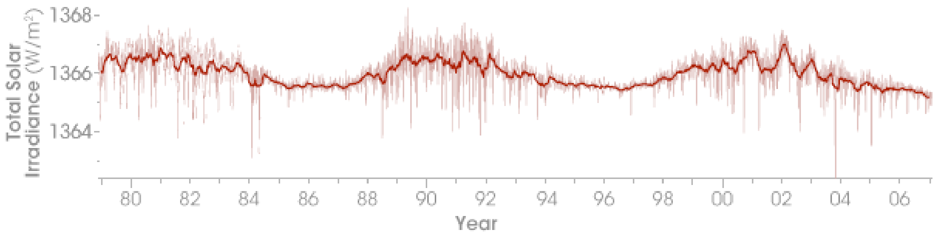



About half the carbon dioxide emitted into the air from burning fossil fuels dissolves in the ocean. While this process reduces the amount of greenhouse gases in the atmosphere, it raises the acidity of ocean water (just like carbonated water, which is acidic). This map shows the total amount of human-made carbon dioxide in ocean water from the surface to the sea floor. Blue areas have low amounts, while yellow regions are rich in anthropogenic carbon dioxide. High amounts occur where currents carry the carbon-dioxide-rich surface water into the ocean depths. (Map adapted from Sabine et al., 2004.)

Along with paleoclimate data, these sources reveal that the planet has been warming for at least the last 400 years, and possibly the last 1000 years. As of now, warming after 1950 cannot be explained without accounting for greenhouse gases; natural influences such as volcanic eruptions or changes in the Sun's output cannot account for the observed temperatures changes.

Occasional violent volcanic eruptions, such as Mt. Pinatubo, pump gases like sulfur dioxide and aerosols high into the atmosphere where they can linger for more than a year, reflecting sunlight and shading Earth's surface. The cooling influence of this aerosol "shade" is greater than the warming influence of the volcanoes' greenhouse gas emissions, and therefore such eruptions cannot account for the recent warming trend.

An increase in solar output also falls short of explaining recent warming. NASA satellites have been measuring the Sun's output since 1978, and while the Sun's activity has varied a little, the observed changes were not large enough to account for the warming recorded during the same period. Climate simulations of global temperature changes based only on solar variability and volcanic aerosols since 1750—omitting greenhouse gases— are able to fit the record of global temperatures only up until about 1950.

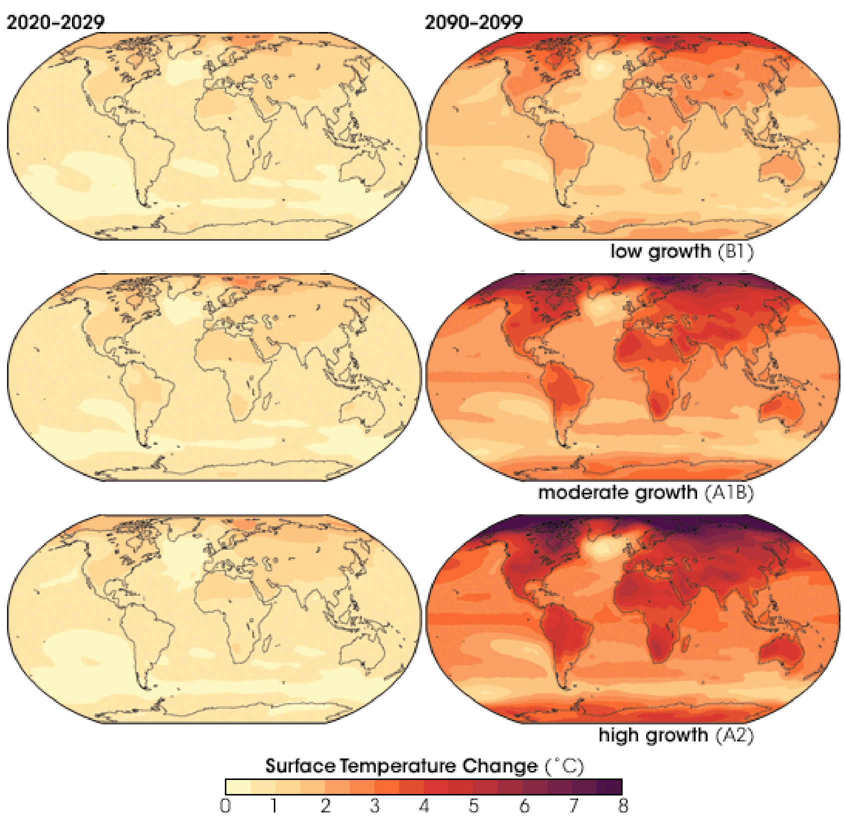



The only viable explanation for warming after 1950 is an increase in greenhouse gases. It is well established theoretically why carbon dioxide, methane, and other greenhouse gases should heat the planet, and observations show that they have.

Satellite measurements of the Sun's activity since 1978 reveal the Sun's eleven-year sunspot cycle. When the Sun is more active, it sends slightly more energy to the Earth, and energy levels dip when the Sun is quieter. Though the Sun's activity has varied over the past three decades, the variation is too small to explain the rapid warming seen on Earth during the same period. (Graph adapted from the PMOD World Radiation Center.)

#### Predicting Future Warming

As the world consumes ever more fossil fuel energy, greenhouse gas concentrations will continue to rise, and Earth's average surface temperature will rise with them. Based on plausible emission scenarios, the IPCC estimates that average surface temperatures could rise between 2°C and 6°C by the end of the 21st century.

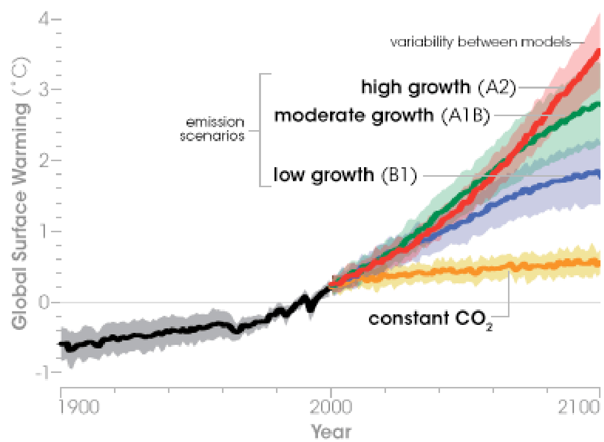



At first glance, these numbers probably do not seem threatening. After all, temperatures typically change a few tens of degrees whenever a storm front moves through. Such temperature changes, however, represent day-to-day regional fluctuations. When surface temperatures are averaged over the entire globe for extended periods of time, it turns out that the average is remarkably stable. Not since the end of

Global warming will not affect all places on Earth the same way. Climate models predict that warming will be greatest in the Arctic and over land. Models also give a range of temperature predictions based on different emission scenarios. If humans limit greenhouse gas emissions (low growth), then the temperature change over the next century will be smaller than the change predicted if humans do not limit emissions (high growth). (©2007 IPCC WG1 AR-4.)

the last ice age 20,000 years ago, when Earth warmed about 5°C, has the average surface temperature changed as dramatically as the 2°C to 6°C change that scientists are predicting for the next century.

Scientists predict the range of temperature increase by running different scenarios through climate models. Because scientists can't say how human society may change over the next century, or how certain aspects of the climate system (such as clouds) will respond to global warming, they give a range of temperature estimates. The higher estimates are made on the assumption that the entire world will continue to use more and more fossil fuel per capita. The lower estimates come from best-case scenarios in which environmentally friendly technologies such as fuel cells and solar panels replace much of today's fossil fuel combustion. After inputting estimates for future greenhouse gas emissions, scientists run the models forward into many possible futures to arrive at the range of estimates provided in the IPCC report. The estimates are being used to predict how rising temperatures will affect both people and natural ecosystems. The severity of environmental change will depend on how much the Earth's surface warms over the next century.




The Intergovernmental Panel on Climate Change estimates that Earth will warm between two and six degrees Celsius over the next century. The range in estimate comes from running different emission scenarios through several different global climate models. Scenarios that assume that people will burn more and more fossil fuel provide the estimates in the top end of the temperature range, while scenarios that assume that greenhouse gas emissions will grow slowly give lower temperature predictions. The orange line provides an estimate of what global temperatures would have been if greenhouse gases had stayed at year 2000 levels. (©2007 IPCC WG1 AR-4.)

**Potential Effects of Global Warming**

The most obvious impact of global warming will be changes in both average and extreme temperature and precipitation, but warming will also enhance coastal erosion, lengthen the growing season, melt ice caps and glaciers, and alter the range of some infectious diseases, among other things.

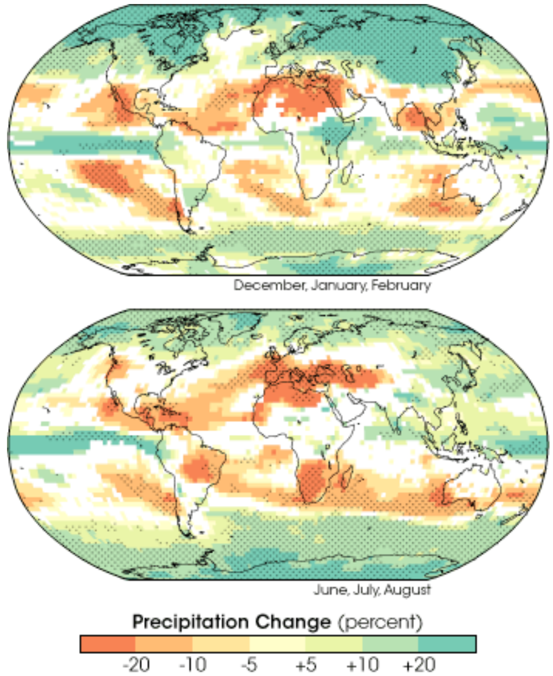
For most places, global warming will result in more hot days and fewer cool days, with the greatest warming happening over land. Longer, more intense heat waves will become more frequent. High latitudes and generally wet places will tend to receive more rainfall, while tropical regions and generally dry places will probably receive less rain. Increases in rainfall will come in the form of bigger, wetter storms, rather than in the form of more rainy days. In between those larger storms will be longer periods of light or no rain, so the frequency of drought will increase. Hurricanes will likely increase in intensity due to warmer ocean surface temperatures.

Global warming will shift major climate patterns, possibly prolonging and intensifying the current drought in the U.S. Southwest. The white ring of bleached rock on the once-red cliffs that surround Lake Powell indicate the drop in water level over the past decade, the result of repeated winters with low snowfall. (Photograph ©2006 Tigresblanco.)

It is impossible to pin any one unusual weather event on global warming, but evidence is emerging that suggests that global warming is already influencing the weather. The IPCC reports that both heat waves and intense rain events have increased in frequency during the last 50 years, and human-induced global warming more likely than not contributed to the trend. Satellite-based rainfall measurements show tropical areas got more rain in the form of large storms or light rainfall instead of moderate storms between 1979 and 2003. Since the 1970s, the area affected by drought and the number of intense tropical cyclones also have increased, trends that IPCC scientists say were more likely than not influenced by human activities, though in the case of cyclones, the record is too sparse to draw any certain conclusions.

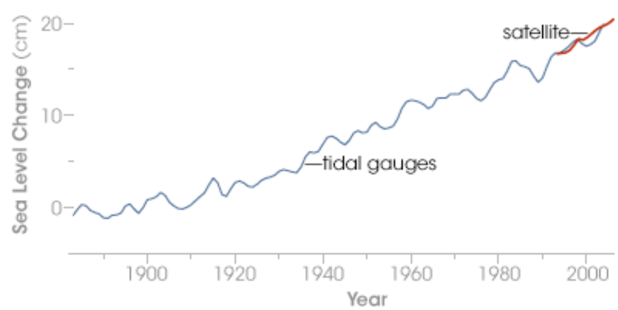
| Phenomena and direction of trend | Likelihood that trend occurred in late 20$^{th}$ century | Likelihood of a human contribution to observed trend | Likelihood of future trends |
|---|---|---|---|
| Warmer and fewer cold days and nights over most land areas | Very likely | Likely | Virtually certain |
| Warmer and more frequent hot days and nights over most land areas | Very likely | Likely (nights) | Virtually certain |
| Warm spells/heat waves. Frequency increases over most land areas | Likely | More likely than not | Very likely |
| Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas | Likely | More likely than not | Very likely |
| Area affected by droughts increases | Likely in many regions since 1970s | More likely than not | Likely |
| Intense tropical cyclone activity increases | Likely in some regions since 1970 | More likely than not | Likely |
| Increased incidence of extreme high sea level (excludes tsunamis) | Likely | More likely than not | Likely |

**Potential Effects of Global Warming**




Apart from driving temperatures up, global warming is likely to cause bigger, more destructive storms, more widespread drought, and coastal damage from high sea levels. With some exceptions, the tropics will likely receive less rain (orange) as the planet warms, while the polar regions will receive more precipitation (green). White areas indicate that fewer than two-thirds of the climate models agreed on how precipitation will change. Stippled areas reveal where more than 90 percent of the models agreed. (©2007 IPCC WG1 AR-4.)

The weather isn't the only thing global warming will impact: rising sea levels will erode coasts and cause more frequent coastal flooding. The problem is serious because as much as 10 percent of the world's population lives in coastal areas less than 10 meters (about 30 feet) above sea level. The IPCC estimates that sea levels will rise between 0.18 and 0.59 meters (0.59 to 1.9 feet) by 2099 because of expanding sea water and melting mountain glaciers.

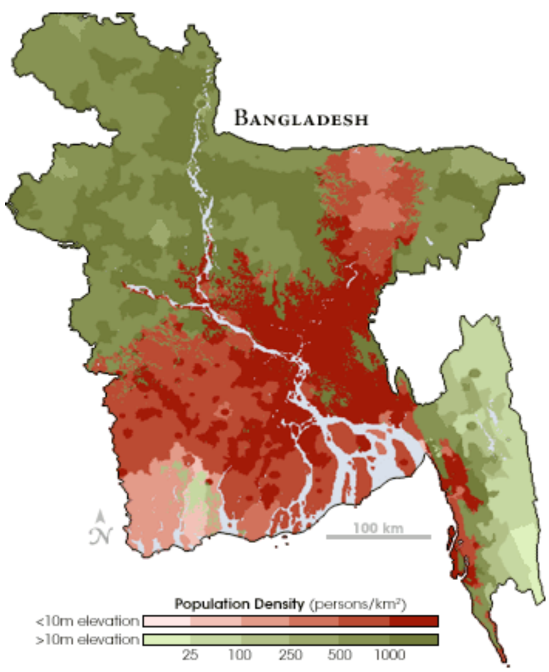



Sea levels crept up about 20 centimeters during the twentieth century. Most of the rise happened because water expands as it warms, though melting mountain glaciers also contributed to the change. Sea levels are predicted to go up between 0.18 and 0.59 meters over the next century, though the increase could be greater if ice sheets in Greenland and Antarctica melt more quickly than predicted. Higher sea levels will erode coastlines and cause more frequent flooding. (Graph ©2007 Robert Rohde.)

These estimates of sea level rise may be low, however, because they do not account for changes in the rate of melt from the world's major ice sheets. As temperatures rise, ice will melt more quickly. New satellite measurements reveal that the Greenland and West Antarctic ice sheets are shedding about 125 billion tons of ice per year—enough to raise sea levels by 0.35 millimeters (0.01 inches) per year. If the melting were to accelerate, the rise in sea level could be significantly higher. For instance, the last time global temperatures were a degree or so warmer than today, sea levels were about 6 meters (20 feet) higher, with the water mainly coming from the melting of the Greenland and the West Antarctic ice sheets. Neither ice sheet is likely to disappear before 2100, but there is the danger that global warming could initiate massive losses from the Greenland and Antarctic ice sheets that will continue or even accelerate over future centuries.

Global warming is also putting pressure on ecosystems, the plants and animals that co-exist in a particular climate. Warmer temperatures have already shifted the growing season in many parts of the globe. Spring is coming earlier, and that means that migrating animals have to start earlier to follow food sources. And since the growing season is longer, plants need more water to keep growing or they will dry out, increasing the risk of fires. Shorter, milder winters fail to kill insects, increasing the risk that an infestation will destroy an ecosystem. As the growing season progresses, maximum daily temperatures increase, sometimes beyond the tolerance of the plant or animal. To survive the climbing temperatures, both marine and land-based plants and animals have started to migrate towards the poles. Those species that cannot migrate or adapt face extinction. The IPCC estimates that 20-30 percent of plant and animal species will be at risk of extinction if temperatures climb more than 1.5° to 2.5°C.

The people who will be hardest hit will be residents of poorer countries who do not have the resources to fend off changes in climate. As tropical temperature zones expand, the reach of some infectious diseases like malaria will change. More intense rains and hurricanes, rising sea levels, and fast-melting mountain glaciers will lead to more severe flooding. Hotter summers and more frequent fires will lead to more cases of heat stroke and deaths, and to higher levels of near-surface ozone and smoke, which would cause more 'code red' air quality days. Intense droughts could lead to an increase in malnutrition. On a longer time scale, fresh water will become scarcer during the summer as mountain glaciers disappear, particularly in Asia and parts of North America. On the flip side, warmer winters will lead to fewer cold-related deaths, and the longer growing season could increase food production in some temperate areas.




As much as 10 percent of the world's population lives in coastal regions where the elevation is less than 10 meters above sea level. These communities will become increasingly prone to storm damage and flooding as sea levels rise. Among the most vulnerable countries is Bangladesh, which has low elevation, a high population density, and is one of the world's poorest nations. Red areas indicate populations that live less than 10 meters above sea level, while green areas show the population density in areas with an elevation greater than 10 meters. (Image courtesy Socioeconomic Data and Applications Center.)

Ultimately, global warming will impact life on Earth in many ways, but the extent of the change is up to us. Scientists have shown that human emissions of greenhouse gases are pushing global temperatures up, and many aspects of climate are responding to the warming in the way that scientists predicted they would. Ecosystems across the globe are already affected and surprising changes have already taken place. Polar ice caps are melting, plants and animals are migrating, tropical rain is shifting, and droughts are becoming more widespread and frequent. Since greenhouse gases are long-lived, the planet will continue to warm and changes will continue to happen, but the degree to which global warming changes life on Earth depends on our decisions.

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**Links:**

Global Warming Questions & Answers

Real Climate

Surface Temperature Reconstructions for the Last 2,000 Years
U.S. Climate Change Science Program
U.S. Environmental Protection Agency Climate Change Website